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ORIGINAL ARTICLE

Analysis of Performance and Emission of Biodiesel with Perovskite Nanomaterial in Diesel Engine using Taguchi Approach

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ABSTRACT

Currently world is facing crises of fuel and environmental issues, which makes an urgent need for search of renewable alternative fuels as well as fuel additives which reduces emissions. In the present research work a experimentation was carried out to synthesize Perovskite composite nanomaterial $Ba(NiNb)_{0.5}O_3$ (BNN) by conventional solid state reaction method, while analysis of the emission and performance characteristics of single cylinder, water cooled four stroke direct injection CI engine at different engine loads using palm and castor biodiesel and BNN as fuel additive was done. Taguchi method was used for design of experiment. The optimum combinations of emission and performance are obtained for biodiesel with BNN nanomaterial as fuel additive. The results revealed that, Blend B20 and B40 with BNN nanomaterial Shows better results.

Keywords-Brake Specific Fuel Consumption, BTE, BNN, CO, HC, NOx etc.

1. INTRODUCTION

Current study focuses that biodiesel and its derivatives, have received much attention in recent years for diesel engines. Biodiesel is an oxygenated diesel engine fuel that can be obtained from vegetable oils or animal fats by conversion of the triglycerides to esters via transesterification. It has similar properties to those of fossil diesel. Therefore, research on biodiesel derived from vegetable oils and animal fats lead to the study of alternative to petroleum based diesel fuels [1][2][3]. It has been reported by the results of many studies that biodiesel can be used in diesel engines with little or no modifications, and with almost the same performance. Besides it reduces carbon monoxide (CO), unburned hydrocarbons (HC) and smoke emissions. However, some of the results revealed that, when biodiesel mixed with nonmaterial additives there is reduction in emissions. The results vary according to the base vegetable oil or animal fats, the process of biodiesel production as well as biodiesel fuel properties. Therefore, different blends of biodiesels with nanomaterial as an fuel additive were tested in diesel engines at different engine loads [4][5][7]. On the other hand, biodiesel has high viscosity, high density, lower calorific value and poor non-volatility, which leads in pumping problem, atomization problem and poor combustion inside the combustion chamber of a diesel engine. In case of long-term use of vegetable oils in diesel engines, problems such as gumming, injector fouling, piston ring sticking and contamination of lubricating oils are bound to occur [8][9]. All these problems are due to the high viscosity of vegetable oils. Hence, it is necessary to reduce the viscosity of vegetable oil to a more approximate value of diesel. The solution to the problems has been approached in several ways, such as preheating the oils, blending them with diesel, thermal cracking and transesterification [10][12]. In the present research work the biodiesel derived from castor seed oil and palm seed oil has been used, to find out the performance and emission of biodiesel using BNN nanomaterial as additive. The properties of Castor oil biodiesel are given in Table 1. [11]. The properties of Palm biodiesel are given in Table 2. [6]

SYNTHESIS OF COMPOSITE NANOMATERIAL:

Before experimentation Synthesis of Composite Nanomaterial was carry out. The Perovskite nanomaterial material BNN was synthesized by conventional solid state reaction method. For structural characterization, XRD of material was carried out. Xray diffraction pattern shows sharp single peak which indicates crystalline nature of material and it confirms the cubic structure of material [13]. Average crystallite size obtained from XRD data is 50.49nm.

DESIGN OF EXPERIMENT (DOE)

Taguchi method for the design of experiment was used. The 5-level design and 5 number of factors are involved, Which are compression ratio, blend, Fuel, pre-heat temp and load. The total 25 combinations of reading were obtained.

Table 1. Properties of Castor oil biodiesel

Density @ 15^{0}C	0.9268 g/cm^3
Flash Point	190.7°C
Calorific Value	37908 kJ/kg
Ash content	0.02 %
Viscosity at 40°C	15.98 mm^2/s
Pour Point	-45°C
Visual appearance	Viscous pale yellow
Cetane number	50

Table 2. Properties of palm biodiesel

Calorific Value, kJ/kg	37254
Density @ 15^{0}C, kg/m^3	875.1
Calorific Value, kJ/kg	37254
Pour Point	-12°C
Flash Point	175°C
Ash content	0.001%
Viscosity at 40°C, mm^2/s	4.1
Cetane number	52
Visual appearance	Dark Brown liquid

2. EXPERIMENTAL DETAILS

Diesel, Bio-diesel (B100) and its blends B20, B40, B60 and B80 were used to test the engine of the specifications mentioned in Table 3

Table 3. Specifications of engine used

Make	Kirloskar
Type	Single-cylinder, four-stroke, compression ignition diesel engine
Stroke	110 mm
Bore	80 mm
Compression ratio	16.5:1
BMEP at 1500 rpm	5.42 bar
Rated output	3.7 Kw
Rated speed	1500 rpm
Dynamometer	Eddy current, water-cooled with loading unit

The performance and emission characteristics of the engine were studied at different engine loads (25%, 50%, 75%, 100% and 115% of the load corresponding to the load at maximum power at an average engine speed of 1500 rpm). At each load, the engine was stabilized for 20 minutes and then measurement parameters were recorded according to DOE. The engine was loaded using the Eddy current dynamometer. The engine speed in rpm was sensed using a sensor pre-installed in the dynamometer and was recorded from the display on the control panel of the dynamometer. The fuel consumption was measured by burette method for 10cc fuel consumption using a stopwatch. The emissions contents (CO, HC, CO_2, and NO_X) were recorded by AVL DiGas444 analyzer by inserting probe in exhaust port of engine. 2gm of additive (as synthesized BNN nanomaterial) in 1 liter of each biodiesel blend was mixed and additive is mixed with the help of Flocculate machine at the speed of 200rpm for 30 minutes. The readings were taken for atmospheric temperature and further temperatures 45^{O}C, 50^{O}C, 55^{O}C and 60^{O}C were obtained using preheating setup before experimentation. The compression ratio was varied from 16.5-18.5. Injection pressure for this experimentation is kept 190 bar.

3. RESULTS AND DISCUSSION

As per the Design of experimentation, the experimentation was carried out and various outputs of emission and performance characteristics are plotted as shown in figure 1, 2, 3, 4, 5, and 6.

CO Emission:
As indicated in figure no.1 SN ratio is maximum for fuel (Castor + Additive), for blend B20, for compression ratio 16.5, for pre-heat temperature 60 and for 0 load. For best Result SN should be maximum. The Co emission value at optimum combination is 0.035%.

CO_2 Emission:
As indicated in figure no.2 SN ratio is maximum for fuel (Palm + Additive), for blend B40, for compression ratio 17.5, for pre-heat temperature 27 and for 0 load. The CO_2 emission value at optimum combination is 1.5%.

HC Emission:
As indicated in figure no.3 SN ratio is maximum for fuel (Castor + Additive), for blend B40, for compression ratio 18, for pre-heat temperature 55 and for 12 load. The HC emission value at optimum combination is 14 ppm.

NOx Emission:
As indicated in figure no.4 SN ratio is maximum for fuel Palm, for blend B100, for compression ratio 16.5, for pre-heat temperature 55 and for 12loads. The NOx emission value at optimum combination is 202ppm,

Brake Specific Energy Consumption:
As indicated in figure no.5 SN ratio is maximum for fuel (Palm + Additive), for blend B20, for compression ratio 17.5, for pre-heat temperature 27 and for 6loads. The BSFC value at optimum combination is 0.2133 kg/KWh.

Brake Thermal Efficiency:
As indicated in figure no.6 SN ratio is maximum for fuel (Palm+ Additives), for blend B20, for compression ratio 18.0, for pre-heat temperature 24 and for 24 loads. The BTE value at optimum combination is 46%.

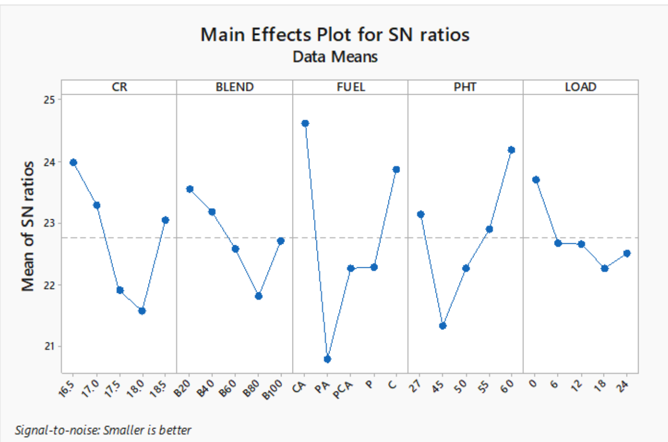

Fig.1: SN Ratio for CO

Optimal combination for CO: 16.5/B20/CA/60/0.

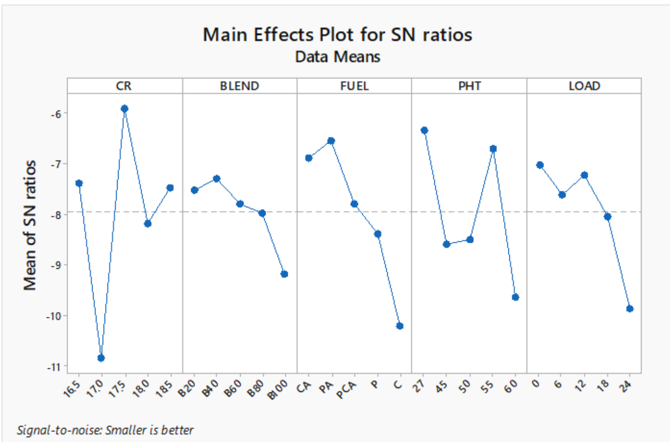

Fig.2: SN Ratio for CO_2

Optimal combination for CO_2: 17.5/B40/PA/27/0

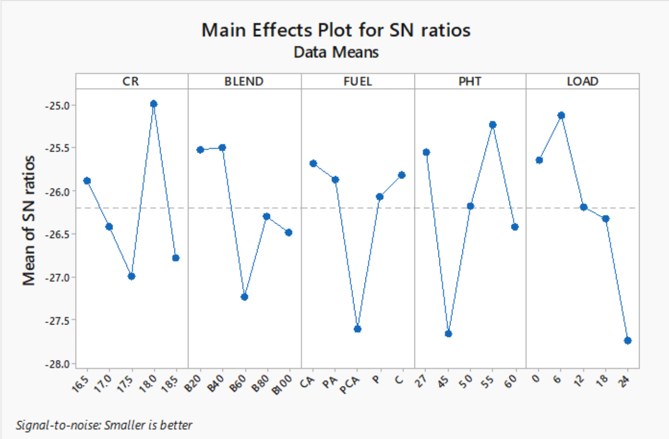

Fig.3: Ratio for HC

Optimal combination for HC: 18/B40/CA/55/12

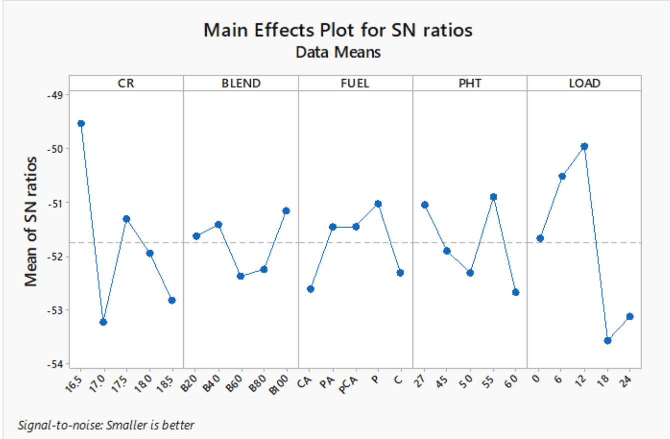

Fig.4: SN Ratio for NOx

Optimal combination for NOx: 16.5/B100/P/55/12

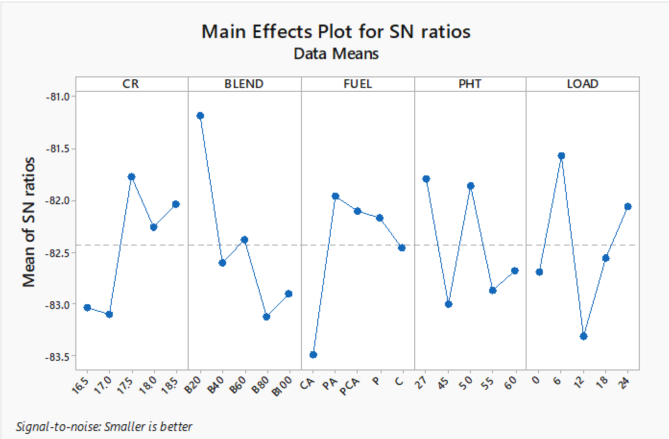

Fig. 5: SN Ratio for Brake Specific Energy Consumption

Optimal combination for BSFC: 17.5/B20/PA/27/6

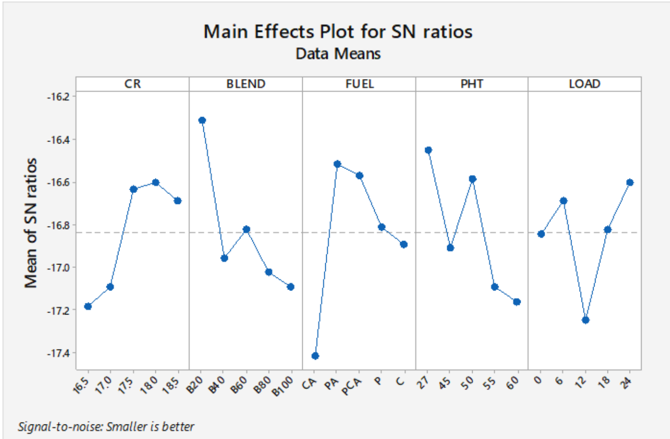

Fig.6: SN Ratio for Brake Thermal Efficiency

Optimal combination for BTE: 18.0/B20/PA/27/24

4. CONCLUSIONS

The aim of the present research work was to study the performance and emission characteristics of CI engine using Palm bio-diesel, Castor bio-diesels & Palm + Castor bio-diesel as a fuel &different blends with composite Nanomaterial BNN as an additive. Using DOE by Taguchi method for experimentation, it is found that from overall observations and results B20 Blend of PA and CA biodiesel shows an optimized trend in almost all combination of experimentation. Being eco-friendly, bio-degradable, non-toxic, & renewable alternative fuel, biodiesel helps in arresting global warming. Thus, biodiesel is a New Era Fuel, in the world of tomorrow and will reduce our dependence on diesel or petrol.

FUTURE SCOPE:

The Multiple Regression method with confirmation test can be use to find the overall optimum combination for less emission and high performance.

ABBREVIATION (FOR FIGURES)

B20 - castor Biodiesel 20% + Diesel 80%
B40 - castor Biodiesel 40% +Diesel 60%
B60 - castor Biodiesel 60% +Diesel 40%
B80 - castor Biodiesel 80%+Diesel 20%
B100- castor Biodiesel 100%
BSEC - Brake Specific Energy Consumption (kJ/kW h)
BMEP -Brake Mean Effective Pressure (bar)
BNN –Barium Nickel Niobate [$Ba(NiNb)_{0.5}O_3$]
HC - Hydro carbon (ppm)

Nox - Nitrogen oxide (ppm)
CO – Carbon Monoxide
CO_2- Carbon Dioxide
PA- Palm + Additive BNN
CA- Castor+ Additive BNN
XRD–X-ray Diffraction

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